Chapter 4
Coal

In the IEO2010 Reference case, world coal consumption increases by 56 percent from 2007 to 2035, and coal's share of world energy consumption grows from 27 percent in 2007 to 28 percent in 2035.

Overview

In the *IEO2010* Reference case, which does not include prospective greenhouse gas reduction policies, world coal consumption increases by 56 percent, from 132 quadrillion Btu in 2007 to 206 quadrillion Btu in 2035 (Figure 60). The growth rate for coal consumption is uneven, averaging 1.1 percent per year from 2007 to 2020 and 2.0 percent per year from 2020 to 2035. The slower growth rate for the earlier period results largely from a decline in coal consumption—primarily in OECD countries—in 2009 during the global economic recession. After 2009, with continuous yearly increases through 2035, world coal consumption rebounds, returning to its 2008 level by 2013. Coal consumption in OECD countries, however, does not return to its 2008 level until 2035. As a result, increased use of coal in non-OECD countries accounts for nearly all of the growth in world coal consumption over the entire period.

In 2007, coal accounted for 27 percent of world energy consumption (Figure 61). Of the coal produced worldwide in 2007, 64 percent was shipped to electricity producers and 33 percent to industrial consumers, with most of the remainder going to consumers in the residential and commercial sectors. Coal's share of total world energy consumption increases to 28 percent in 2035 in the *IEO2010* Reference case. In the electric power sector, its share declines from 44 percent in 2007 to 40 percent in 2020, then increases to 43 percent in 2035.

International coal trade grows by 47 percent in the Reference case, from 21.2 quadrillion Btu in 2008 to 31.2 quadrillion Btu in 2035. The share of total world coal consumption accounted for by internationally traded coal peaks at 18 percent in 2015 and declines to 15 percent after 2025, slightly below the 2008 level of 16 percent. The decline in the share of coal traded primarily reflects the ability of the world's largest coal consumers, China and India, to meet their future coal demand with domestic production.

World coal consumption

OECD coal consumption

In the Reference case, OECD coal consumption declines from 47.9 quadrillion Btu in 2007 to 43.1 quadrillion Btu in 2010 and remains virtually flat until after 2025. After 2025, OECD coal consumption increases to 48.3 quadrillion Btu in 2035, largely because of an increase in natural gas prices that allows coal—in the absence of policies or regulations to limit its use—to compete economically. Almost all of the OECD increase after 2025 is attributable to North America (Figure 62). Over the projection period, slight increases in coal consumption in North America and OECD Asia are, to a large extent, offset by declines in OECD Europe.

Figure 60. World coal consumption by country grouping, 1980-2035 (quadrillion Btu)

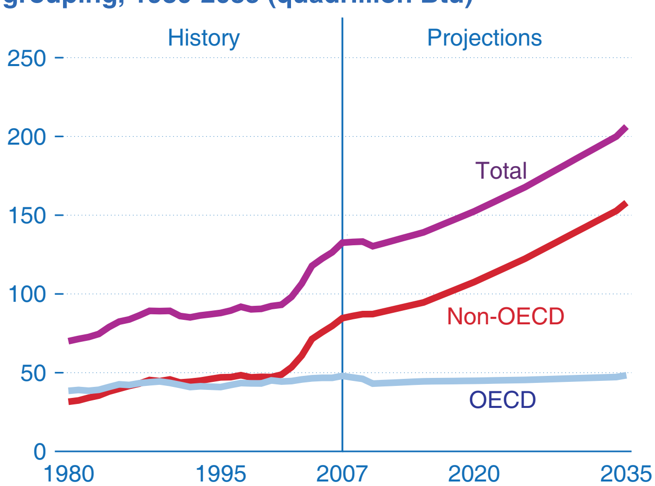
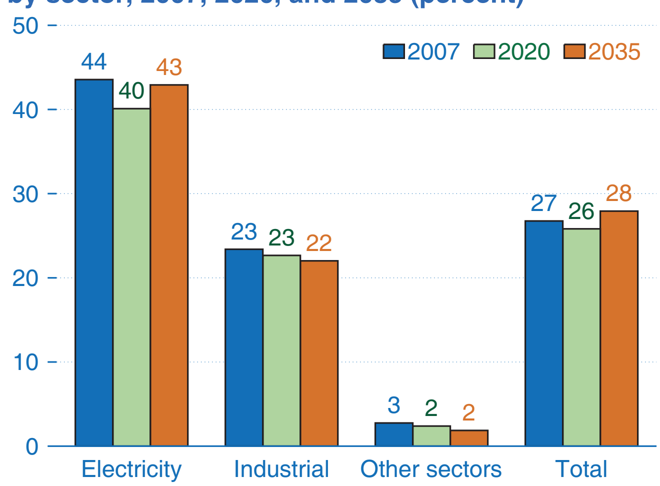


Figure 61. Coal share of world energy consumption by sector, 2007, 2020, and 2035 (percent)



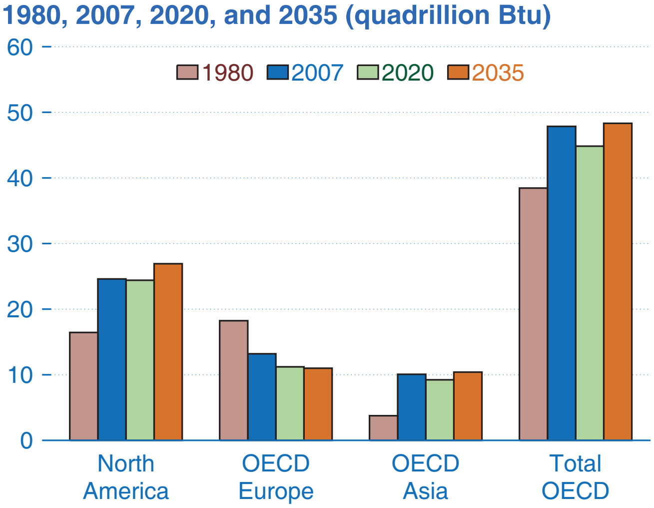
North America

Coal use in the United States totaled 22.7 quadrillion Btu in 2007—92 percent of total coal use in North America and 47 percent of the OECD total. U.S. coal demand rises to 25.1 quadrillion Btu in 2035 in the Reference case. Coal's share of total U.S. electricity generation (including electricity produced at combined heat and power plants in the industrial and commercial sectors) declines from 48 percent in 2007 to 44 percent in 2035.

Increasing use of coal for electricity generation at new and existing plants, combined with the startup of several coal-to-liquids (CTL) plants toward the end of the projection, leads to modest growth in U.S. coal consumption, averaging 0.4 percent per year from 2007 to 2035. Although an assumed increase in the cost of capital for greenhouse-gas-intensive technologies dampens investment in new coal-fired power plants in the United States, the increase in coal-fired electricity generation still is substantial, exceeded only by growth in generation from renewables. Increased generation from coal-fired power plants accounts for 26 percent of the growth in total U.S. electricity generation from 2007 to 2035, while increased generation from renewables (including conventional hydroelectric resources) accounts for 49 percent of the growth. U.S. production of coal-based synthetic liquids increases to 243,000 barrels per day in 2035.

In Canada and Mexico, there are only minor changes in coal consumption over the projection period: a decrease of 0.3 quadrillion Btu in Canada from 2007 to 2035, and an increase of 0.2 quadrillion Btu in Mexico. The decline in Canada's coal consumption is attributable primarily to the Ontario government's plans to phase out the Province's remaining 6.1 gigawatts of coal-fired generating capacity by the end of 2014 [*1*]. In a recent announcement, Ontario Power Generation indicated that approximately 2 gigawatts of coal-fired generating capacity at its Nanticoke and Lambton plants will be retired in late 2010. In Mexico, an additional 0.7 gigawatts of coal-fired generating capacity is scheduled to be completed in 2010 at the existing 2.1-gigawatt Petacalco plant on the Pacific coast [*2*].

Figure 62. OECD coal consumption by region, 1980, 2007, 2020, and 2035 (quadrillion Btu)



OECD Europe

Total coal consumption in the countries of OECD Europe declines in the *IEO2010* Reference case from 13.2 quadrillion Btu in 2007 (28 percent of the OECD total) to 11.0 quadrillion Btu in 2035 (23 percent). In 2007, the electricity and industrial sectors accounted for 95 percent of the coal consumed in OECD Europe, with electricity producers using 9.0 quadrillion Btu of coal and industrial plants using 3.6 quadrillion Btu. Over the projection period, the use of coal declines in both sectors, falling at an average rate of 1.6 percent per year in the industrial sector and 0.3 percent per year in the electricity sector. In 2035, OECD Europe's electric power sector accounts for 75 percent of the region's total coal use, up from 68 percent in 2007.

Although total installed coal-fired electricity generating capacity in OECD Europe declines from 200 gigawatts in 2007 to 177 gigawatts in 2035, coal remains an important component of Europe's power generation, providing nearly one-fifth or the region's total generation in 2035. Plans to retire aging and inefficient generating capacity will, to some extent, be offset by new coal-fired capacity. Currently, between 15 and 20 gigawatts of new coal-fired generating capacity is under construction in OECD Europe, with projects in Germany representing more than one-half of the new construction [*3*]. In addition, there are plans to refurbish some existing coal-fired capacity to make it more efficient.

OECD Asia

The slight increase in coal consumption for the OECD Asia region in the Reference case is the net result of two divergent trends, consisting of a decline in coal use of 1.1 quadrillion Btu for Japan and an increase of 1.3 quadrillion Btu projected for South Korea from 2007 to 2035. Japan is the region's largest coal-consuming nation, but declining population and increasing reliance on nuclear power for electricity generation lowers the demand for coal in the future.

Unlike Japan, Australia and New Zealand increase their coal consumption slightly, by an average of 0.2 percent per year, from 2.9 quadrillion Btu in 2007 to 3.0 quadrillion Btu in 2035. Of the two countries, Australia is by far the larger coal consumer, with 97 percent of the regional total in 2007. With substantial coal reserves (primarily in Australia), the region continues to rely heavily on coal for electricity generation; however, coal's share of total generation declines gradually. Compared with coal, generation from both renewables and natural gas increases at a more rapid pace, so that those fuels capture an increasing share of Australia/New Zealand's total generation. Coal-fired power plants supplied 70 percent of the region's total electricity generation in 2007, as compared with a 58-percent share in 2035.

South Korea is OECD Asia's fastest-growing consumer of coal. Its coal use increases by an average of 1.6 percent per year, from 2.3 quadrillion Btu in 2007 to 3.6 quadrillion Btu in 2035. The 56-percent overall increase from 2007 to 2035 results primarily from growing demand for coal in the electric power sector. According to South Korea's most recent long-term power plan, published in late 2008, the country's generating companies plan to add as much as 15 gigawatts of new coal-fired generating capacity during the years 2008 through 2022 [*4*].

Non-OECD coal consumption

In contrast to coal consumption in OECD economies, fast-paced growth is projected for non-OECD nations, particularly among the Asian economies. Led by strong economic growth and rising energy demand in non-OECD Asia, total coal consumption in non-OECD countries increases to 157.9 quadrillion Btu in 2035, growing by 87 percent from the 2007 total of 84.6 quadrillion Btu (Figure 63). The substantial increase in non-OECD coal consumption illustrates the importance of coal in meeting the region's energy needs. Over the entire period from 2007 to 2035, coal accounts for about one-third of total non-OECD energy consumption.

Non-OECD Asia

The countries of non-OECD Asia account for 95 percent of the projected increase in world coal consumption from 2007 to 2035. Strong economic growth is expected for non-OECD Asia, averaging 5.2 percent per year from 2007 to 2035, with China's economy averaging 5.8 percent per year and India's 5.0 percent per year. In *IEO2010*, much of the increase in demand for energy in non-OECD Asia, particularly in the electric power and industrial sectors, is met with coal.

Coal use in China's electricity sector increases from 27.7 quadrillion Btu in 2007 to 72.2 quadrillion Btu in 2035, at an average rate of 3.5 percent per year (Figure 64). In comparison, coal consumption in the U.S. electric power sector grows by 0.4 percent annually, from 20.8 quadrillion Btu in 2007 to 23.1 quadrillion Btu in 2035. At the end of 2007, China had an estimated 496 gigawatts of coal-fired capacity in operation. To meet the demand for electricity that accompanies its rapid economic growth, an additional 736 gigawatts of coal-fired capacity (net of retirements) is expected to be brought on line in China by 2035, requiring large financial investments in new coal-fired power plants and associated electricity transmission and distribution systems. In the near term, the *IEO2010* projections show a substantial amount of new coal plant builds, with 138 gigawatts of capacity additions between 2007 and 2010. Notwithstanding the substantial growth in coal-fired generating capacity and generation projected for China in the *IEO2010* Reference case, coal's share of the country's total generation declines from 80 percent in 2007 to 74 percent in 2035, as generation from nuclear and renewables grows at an even more rapid pace than generation from coal.

Nearly one-half (49 percent) of China's coal use in 2007 was in the non-electricity sectors, primarily in the industrial sector and notably for the production of steel and pig iron. In the *IEO2010* Reference case, coal consumption in those sectors increases by 13.1 quadrillion Btu (48 percent) from 2007 to 2035. Within the industrial sector, the single largest use of coal is for the production of coke, which in turn is used primarily to produce pig iron. In 2007, Chinese coke plants consumed 459 million tons[18] of coal, representing, on a tonnage basis, about 17 percent of the total amount of coal consumed in all sectors in

Figure 63. Non-OECD coal consumption by region, 1980, 2007, 2020, and 2035 (quadrillion Btu)

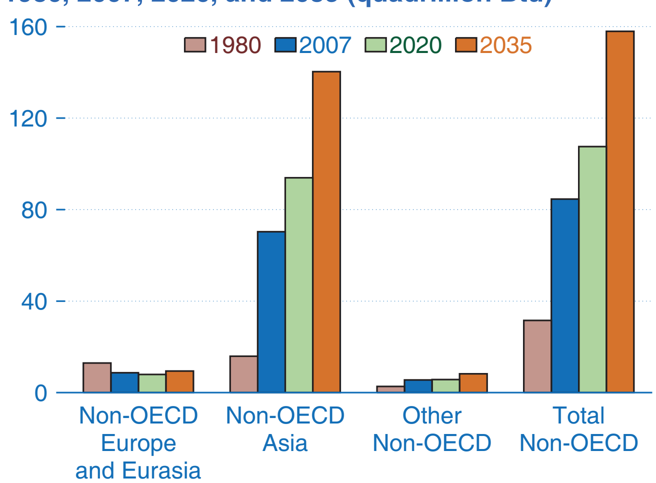
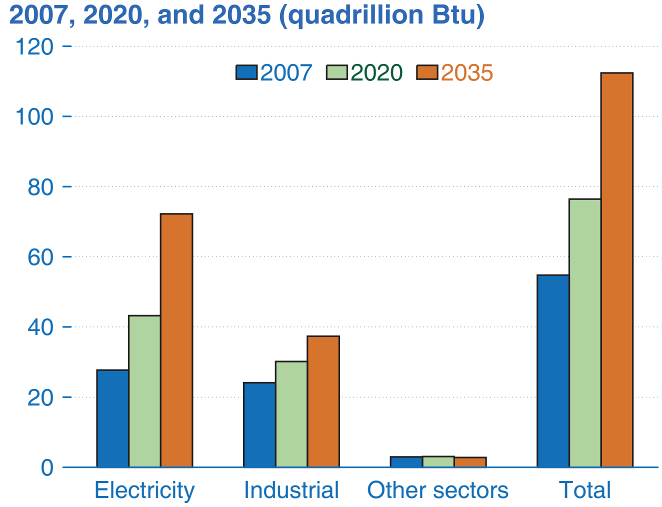


Figure 64. Coal consumption in China by sector, 2007, 2020, and 2035 (quadrillion Btu)



[18] Throughout this chapter, tons refer to short tons (2,000 pounds).

China during 2007 [*5*]. China was the world's leading producer of both steel and pig iron in 2007, accounting for 36 percent of global raw steel output and 50 percent of world pig iron production [*6*].

Coal remains the leading source of energy for China's industrial sector in the Reference case, although its share of industrial energy consumption declines over the projection period, with electricity and other energy sources making up an increasing share of the total. Electricity's share of total industrial energy use rises from 19 percent in 2007 to 32 percent in 2035, while coal's share drops from 60 percent to 47 percent. However, with coal-fired power plants satisfying approximately three-fourths of China's total power generation requirements throughout the period from 2007 to 2035, the increase in electricity demand in the industrial sector can be viewed indirectly as an increase in the demand for coal.

In India, 56 percent of the growth in coal consumption is expected to be in the electric power sector and most of the remainder in the industrial sector. In 2007, India's coal-fired power plants consumed 6.6 quadrillion Btu of coal, representing 65 percent of the country's total coal demand. Coal use for electricity generation in India grows by 1.3 percent per year on average, to 9.5 quadrillion Btu in 2035, requiring an additional 51 gigawatts of coal-fired capacity (net of retirements). As a result, India's coal-fired generating capacity increases from 84 gigawatts in 2007 to 135 gigawatts in 2035. Despite a 45-percent increase in the use of coal for electricity generation over the projection period, growth in generation from natural gas, nuclear power, and renewable energy sources is even more rapid, and coal's share of India's total generation declines from 71 percent in 2007 to 51 percent in 2035.

In the nations of non-OECD Asia outside China and India, coal consumption grows by an average of 3.0 percent per year, from 5.4 quadrillion Btu in 2007 to 12.4 quadrillion Btu in 2035. Growing demand for energy in the region's electric power and industrial sectors drives the increase in coal use. In the electric power sector, significant growth in coal consumption is expected in Indonesia and Vietnam, where considerable amounts of new coal-fired generating capacity are expected to be built.

Non-OECD Europe and Eurasia

Coal consumption in non-OECD Europe and Eurasia increases in the *IEO2010* Reference case by an average of 0.3 percent per year, from 8.7 quadrillion Btu in 2007 to 9.4 quadrillion Btu in 2035. Russia is the region's largest coal consumer, at 4.3 quadrillion Btu in 2007, or 49 percent of the total for non-OECD Europe and Eurasia. Coal met 14 percent of Russia's total energy requirements in 2007, and coal-fired power plants provided 23 percent of its electricity. In the Reference case, coal consumption in Russia in 2035 totals 5.2 quadrillion Btu, its share of total energy consumption increases slightly to 15 percent, and its share of electricity generation increases to 24 percent. Although natural gas is the leading source of electricity generation in Russia, and continues to hold that position throughout the projection, increased generation from nuclear and coal-fired power plants, taken together, accounts for 68 percent of the country's generation growth. The natural gas share of Russia's total electricity generation declines from 40 percent in 2007 to 32 percent in 2035 in the Reference case, and the nuclear share rises from 15 percent to 25 percent.

Coal consumption in the other countries of non-OECD Europe and Eurasia declines slightly, from 4.4 quadrillion Btu in 2007 to 4.1 quadrillion Btu in 2035. The use of coal declines in every end-use sector of the region except for the electric power sector, where it increases by an average of 0.7 percent per year. From 2007 to 2035, coal, natural gas, and nuclear power satisfy much of the additional electricity requirement for non-OECD Europe and Eurasia, with increased output from coal-fired plants meeting 18 percent of the growth, natural-gas-fired plants 41 percent, and nuclear plants 29 percent. Coal's share of total electricity generation declines from 29 percent in 2007 to 25 percent in 2035. Currently, a number of new coal-fired power projects are in the planning stages in the region [*7*]. Locally mined lignite is the proposed fuel for most of the proposed plants, although imported coal is the likely fuel source for several plants that may be constructed in coastal areas.

Africa

Africa's coal consumption increases by 1.9 quadrillion Btu from 2007 to 2035 in the Reference case. South Africa currently accounts for 91 percent of the coal consumed on the continent and is expected to continue to account for much of Africa's total coal consumption over the projection period.

In South Africa, increasing demand for electricity in recent years has led to a decision by Eskom, the country's state-owned electricity supplier, to restart three large coal-fired plants (Camden, Grootvlei, and Komati) that have been closed for more than a decade [*8*]. The individual units at those plants, with a combined generating capacity of 3.8 gigawatts, are scheduled to return to service by 2011. In addition, Eskom is proceeding with the construction of two new coal-fired power plants, Medupi and Kusile, with a combined generating capacity of 9.6 gigawatts. The 12 individual units at the Medupi and Kusile plants are scheduled to be fully operational by the end of 2016. In April 2010, the World Bank approved a $3.8 billion loan for Eskom to help with the financing of several energy-related projects, including $3.1 billion allocated for completion of the Medupi plant [*9*].

Recent power shortages and a general lack of spare generating capacity in southern Africa also have led to increased interest in new coal-fired power projects in countries other than South Africa. Of particular significance are major investments being made by several international energy companies to develop coal reserves in Mozambique and Botswana for the purpose of supplying both domestic coal-fired generating plants and international markets[*10*].

In the industrial sector, increasing coal use results from production of steam and process heat for industrial applications, production of coke for the steel industry, and production of coal-based synthetic liquids. Currently, two large-scale CTL plants in South Africa (Sasol II and Sasol III) can supply up to 150,000 barrels of synthetic liquids per day and account for about 20 percent of the country's total liquid fuel supply [*11*]. About 25 percent of South Africa's total coal consumption is used for synthetic liquids production [*12*].

Central and South America

Central and South America consumed 0.9 quadrillion Btu of coal in 2007. Brazil, with the world's ninth-largest steel production in 2007, accounted for 51 percent of the region's coal demand, and Chile, Colombia, Puerto Rico, Argentina, and Peru accounted for most of the remainder [*13*]. In the Reference case, coal consumption in Central and South America increases by 0.8 quadrillion Btu from 2007 to 2035, with most of the increase in Brazil, primarily for coke manufacture and electricity generation. Brazil's steel companies currently plan to expand production capacity by a substantial amount over the mid-term to meet increasing domestic and international demand for steel [*14*].

Middle East

Countries in the Middle East consumed 0.4 quadrillion Btu of coal in 2007. Israel accounted for 85 percent of the total and Iran most of the remainder. The region's coal use remains near the current level through 2035.

World coal production

In the *IEO2010* Reference case, 75 percent of the increase in world coal production occurs in China, where output rises by 54.7 quadrillion Btu from 2007 to 2035 (Table 8). This outlook is based on the assumption that much of the demand for coal in China will continue to be met by domestic production. Other substantial increases in regional coal production from 2007 to 2035 include 7.1 quadrillion Btu in Australia/New Zealand (representing 10 percent of the increase in world coal production), 4.0 quadrillion Btu in non-OECD Asia (excluding China), 3.0 quadrillion Btu in Africa, 2.8 quadrillion Btu in the United States, and 2.4 quadrillion Btu in Central and South America.

Most of the growth in coal production in Australia/New Zealand and other Central and South America is based on continuing increases in coal exports, whereas production growth in Africa and non-OECD Asia (excluding China) is attributable to both rising levels of coal consumption and increasing exports. For the United States, growth in coal production is a result primarily of increases in domestic coal consumption. The projected increases in coal production for these six regions dominate the overall trends for the OECD and non-OECD regions as a whole, accounting for more than 100 percent of the increase in net production for OECD countries and 97 percent of the net increase for non-OECD countries.

World coal trade

With the global recession, international trade in coal in 2009, moving via ship or barge, is estimated to have fallen slightly from the 2008 level (even though China's coal imports doubled in 2009 compared with 2008). Still, the rapid decommissioning of small coal mines in China's historically most productive coal province (Shanxi), a cold winter in China, delays in some infrastructure projects in exporting nations, and continued transportation bottlenecks kept international coal supply tight in 2009. The volume of seaborne coal trade continues its long-term trend, rising through 2035 mainly in response to large increases in non-OECD coal demand—predominantly from China and India.

Although both steam coal and coking coal are traded internationally, most of the trade is in steam coal, which represents 72 percent of world coal trade in 2035 (slightly higher than the current level of 70 percent). In 2008, 58 percent of the world's exported steam coal was imported by Asian countries, and their share of the total increases to 72 percent in 2035.

The share of coking coal imports destined for Asian countries increases from 62 percent in 2008 to an estimated 70 percent in 2009 and never falls below 67 percent in the Reference case. China, India, and Iran were the only significant steel-producing countries in which steel production increased from 2008 to 2009.[19] China increased its production by 73 million tons, India by 2 million tons, and Iran by 1 million tons [*15*]. Most of the other countries producing crude steel reduced their steel production by double-digit percentages from 2008 to 2009, and there were similar declines in blast furnace iron production, part of the steelmaking process that requires coking coal. Although some coke plants have been closed down since 2008, most appear to be

[19] Ecuador, Morocco, and Saudi Arabia increased raw steel production from 64,000 to 291,00 tons, from 527,000 tons to 528,000 tons, and from 5,145,000 tons to 5,170,000 tons, respectively, from 2008 to 2009.

operating still (although at lower utilization rates since the recession began) and are expected to see increased utilization as the global economy improves.

International coal trade, which accounted for about 16 percent of total world coal consumption in 2008, grows at an average annual rate of 1.4 percent in the Reference case, from about 21 quadrillion Btu in 2008 to 31 quadrillion Btu in 2035. Because the largest increases are projected for non-OECD Asia—particularly China, which meets most of the increase in its coal demand with domestic supply rather than seaborne imports—the share of coal trade as a percentage of global coal consumption falls to 15 percent in 2035. Australia and Indonesia are well situated geographically to continue as the leading suppliers of internationally traded coal, especially to Asia, over the period. In addition, South America is poised to expand its role as an international supplier of coal, primarily as a result of increasing coal production in Colombia.

Coal imports

Asia

In the *IEO2010* Reference case, Asia remains the world's largest importer of coal. The region already accounts for 59 percent of total world imports (12.6 quadrillion Btu), and its share increases to 70 percent (21.8 quadrillion Btu) in 2035 (Table 9 and Figure 65). Japan is currently Asia's largest coal importer (Figure 66), and although 2001 marked the final year of significant Japanese coal production [*16*], the country has continued to rely on coal to meet its energy requirements. Australia provides about 62 percent of Japan's coal supply (both steam and metallurgical coal), and China supplies about 20 percent of its steam coal imports. Because Japan lacks significant resources of its own, it is likely to continue seeking diverse sources of coal supply for the long term. Japanese companies also have pursued investments in coal production in other countries, including Russia and

Table 8. World coal production by region, 2007-2035 (quadrillion Btu)

Region	2007	2010	2015	2020	2025	2030	2035	Average annual percent change, 2007-2035
OECD North America	**25.3**	**23.4**	**25.3**	**26.0**	**26.6**	**27.4**	**28.8**	**0.5**
United States	23.5	21.3	23.3	24.1	24.6	25.4	26.3	0.4
Canada	1.6	1.8	1.8	1.8	1.8	2.0	2.2	1.1
Mexico	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1
OECD Europe	**7.2**	**6.8**	**5.4**	**5.5**	**5.2**	**5.2**	**5.4**	**-1.0**
OECD Asia	**9.1**	**10.9**	**11.6**	**11.4**	**12.3**	**13.7**	**15.1**	**1.9**
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—
South Korea	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-3.4
Australia/New Zealand	9.0	10.8	11.6	11.4	12.3	13.7	15.1	1.9
Total OECD	**41.6**	**41.0**	**42.3**	**42.9**	**44.1**	**46.4**	**49.3**	**0.6**
Non-OECD Europe and Eurasia	**10.2**	**9.8**	**10.0**	**10.0**	**10.1**	**10.7**	**11.9**	**0.5**
Russia	5.9	6.0	6.3	6.3	6.4	6.9	7.9	1.1
Other	4.3	3.8	3.7	3.7	3.7	3.8	4.0	-0.3
Non-OECD Asia	**72.8**	**71.8**	**78.0**	**89.5**	**103.0**	**117.2**	**132.0**	**2.2**
China	55.3	56.3	63.1	74.5	86.5	98.3	110.0	2.5
India	8.7	8.3	7.8	7.8	8.3	8.7	9.5	0.3
Other	8.8	7.2	7.0	7.2	8.2	10.1	12.5	1.3
Middle East	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**2.1**
Africa	**5.9**	**5.5**	**6.2**	**6.5**	**6.9**	**7.6**	**9.0**	**1.5**
Central and South America	**2.2**	**2.3**	**2.8**	**3.8**	**4.0**	**4.2**	**4.6**	**2.6**
Brazil	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Other	2.1	2.2	2.7	3.7	3.9	4.2	4.5	2.7
Total Non-OECD	**91.1**	**89.4**	**97.1**	**109.9**	**124.0**	**139.8**	**157.5**	**2.0**
Total World	**132.7**	**130.4**	**139.4**	**152.8**	**168.2**	**186.2**	**206.9**	**1.6**

Note: With the exception of North America, non-seaborne coal trade is not represented in the projections. As a result, the projected levels of production assume that net non-seaborne coal trade will balance out across the *IEO2010* regions. Currently, a significant amount of non-seaborne coal trade takes place in Eurasia, represented by exports of steam coal from Kazakhstan to Russia and exports of coking coal from Russia to Ukraine.

Table 9. World coal flows by importing and exporting regions, Reference case, 2008, 2020, and 2035 (quadrillion Btu)

	Importers											
	Steam				Coking				Total			
Exporters	Europe[a]	Asia	Americas	Total[b]	Europe[a]	Asia[c]	Americas	Total[b]	Europe[a]	Asia	Americas	Total[b]
						2008						
Australia	0.12	2.98	0.04	**3.17**	0.76	2.67	0.20	**3.62**	0.88	5.64	0.23	**6.79**
United States	0.36	0.02	0.45	**0.83**	0.76	0.11	0.30	**1.17**	1.11	0.13	0.75	**1.99**
Southern Africa[d]	1.17	0.26	0.05	**1.55**	0.00	0.00	0.00	**0.01**	1.17	0.26	0.05	**1.56**
Eurasia	1.16	0.38	0.00	**1.55**	0.08	0.08	0.00	**0.16**	1.24	0.47	0.00	**1.71**
Poland	0.11	0.00	0.00	**0.11**	0.00	0.00	0.00	**0.00**	0.11	0.00	0.00	**0.11**
Canada	0.01	0.11	0.03	**0.14**	0.19	0.43	0.11	**0.74**	0.20	0.55	0.14	**0.88**
China	0.04	1.02	0.00	**1.07**	0.00	0.09	0.00	**0.09**	0.04	1.11	0.00	**1.16**
South America[e]	0.96	0.00	0.99	**1.95**	0.00	0.00	0.00	**0.00**	0.96	0.00	0.99	**1.95**
Vietnam	0.01	0.45	0.00	**0.46**	0.00	0.00	0.00	**0.00**	0.01	0.45	0.00	**0.46**
Indonesia[f]	0.49	3.45	0.10	**4.07**	0.00	0.53	0.00	**0.54**	0.49	3.99	0.10	**4.60**
Total	**4.42**	**8.67**	**1.66**	**14.89**	**1.80**	**3.92**	**0.60**	**6.33**	**6.21**	**12.59**	**2.26**	**21.23**
						2020						
Australia	0.00	4.19	0.00	**4.19**	0.32	3.97	0.04	**4.33**	0.32	8.15	0.04	**8.52**
United States	0.16	0.04	0.06	**0.26**	0.74	0.17	0.40	**1.31**	0.90	0.20	0.47	**1.57**
Southern Africa[d]	1.01	0.76	0.20	**1.96**	0.05	0.34	0.02	**0.40**	1.05	1.09	0.21	**2.36**
Eurasia	1.43	0.51	0.00	**1.94**	0.07	0.21	0.00	**0.28**	1.50	0.72	0.00	**2.22**
Poland	0.10	0.00	0.01	**0.11**	0.03	0.00	0.00	**0.03**	0.13	0.00	0.01	**0.14**
Canada	0.11	0.00	0.00	**0.11**	0.32	0.25	0.30	**0.87**	0.43	0.25	0.30	**0.98**
China	0.00	0.97	0.00	**0.97**	0.00	0.02	0.00	**0.02**	0.00	0.99	0.00	**0.99**
South America[e]	2.13	0.37	1.25	**3.75**	0.00	0.00	0.00	**0.00**	2.13	0.37	1.25	**3.75**
Vietnam	0.00	0.24	0.00	**0.24**	0.00	0.00	0.00	**0.00**	0.00	0.24	0.00	**0.24**
Indonesia[f]	0.00	4.13	0.09	**4.21**	0.01	0.49	0.00	**0.50**	0.01	4.62	0.09	**4.72**
Total	**4.93**	**11.20**	**1.61**	**17.74**	**1.54**	**5.44**	**0.77**	**7.75**	**6.47**	**16.64**	**2.38**	**25.49**
						2035						
Australia	0.06	6.77	0.00	**6.83**	0.38	4.67	0.22	**5.27**	0.44	11.44	0.22	**12.10**
United States	0.23	0.09	0.05	**0.37**	0.49	0.04	0.65	**1.19**	0.72	0.14	0.71	**1.56**
Southern Africa[d]	0.70	1.67	0.18	**2.55**	0.05	0.32	0.03	**0.40**	0.75	1.99	0.21	**2.95**
Eurasia	1.37	0.64	0.13	**2.13**	0.22	0.27	0.00	**0.49**	1.58	0.91	0.13	**2.62**
Poland	0.07	0.00	0.02	**0.09**	0.01	0.00	0.00	**0.01**	0.09	0.00	0.02	**0.10**
Canada	0.21	0.00	0.00	**0.21**	0.40	0.22	0.37	**0.99**	0.61	0.22	0.37	**1.20**
China	0.00	0.97	0.00	**0.97**	0.00	0.02	0.00	**0.02**	0.00	0.99	0.00	**0.99**
South America[e]	2.09	1.06	1.38	**4.53**	0.00	0.00	0.00	**0.00**	2.09	1.06	1.38	**4.53**
Vietnam	0.00	0.24	0.00	**0.24**	0.00	0.00	0.00	**0.00**	0.00	0.24	0.00	**0.24**
Indonesia[f]	0.00	4.29	0.12	**4.41**	0.01	0.49	0.00	**0.50**	0.01	4.78	0.12	**4.91**
Total	**4.73**	**15.73**	**1.87**	**22.32**	**1.56**	**6.04**	**1.29**	**8.88**	**6.28**	**21.77**	**3.16**	**31.21**

[a]Includes coal shipments to the Middle East and Africa.

[b]In 2008, total world coal flows include a balancing item used to reconcile discrepancies between reported exports and imports. The 2008 balancing items by coal type were 0.14 quadrillion Btu (steam coal), 0.01 quadrillion Btu (coking coal), and 0.16 quadrillion Btu (total).

[c]Includes 0.8 quadrillion Btu of coal for pulverized coal injection at blast furnaces shipped to Japanese steelmakers in 2008.

[d]Southern Africa includes South Africa, Mozambique, and Botswana.

[e]Coal exports from South America originate from mines in Colombia and Venezuela.

[f]Includes shipments from other countries not modeled for the projection period. The 2008 exports from other countries by coal type were 0.07 quadrillion Btu (steam coal), 0.03 quadrillion Btu (coking coal), and 0.10 quadrillion Btu (total).

Notes: Data exclude non-seaborne shipments of coal to Europe and Asia. Totals may not equal sum of components due to independent rounding.

Sources: SSY Consultancy and Research, Ltd., and EIA.

Canada [*17*]. Japan is a leader in steel production, ranking second only to China [*18*], and continues to import coking coal for use in its steelmaking plants through 2035.

Like Japan, South Korea continues importing most of the coal it consumes through 2035. With planned increases in coal-fired generating capacity, South Korea (in OECD Asia) and Taiwan (in non-OECD Asia) maintain a combined 17 -percent share of world imports in 2035, despite sizable increases in coal imports by other countries.

In 2035, China's coal imports total 3.7 quadrillion Btu in the Reference case. China remains a net importer through 2035, but even with a substantial increase in imports, a preponderant share of the coal consumed in China will continue to be supplied by its own coal mines. Extremely cold weather has played a key role in China's strong coal demand in the winter of 2009-2010. In addition, the unpredictability of China's coal markets raises the level of uncertainty surrounding the world trade projections.

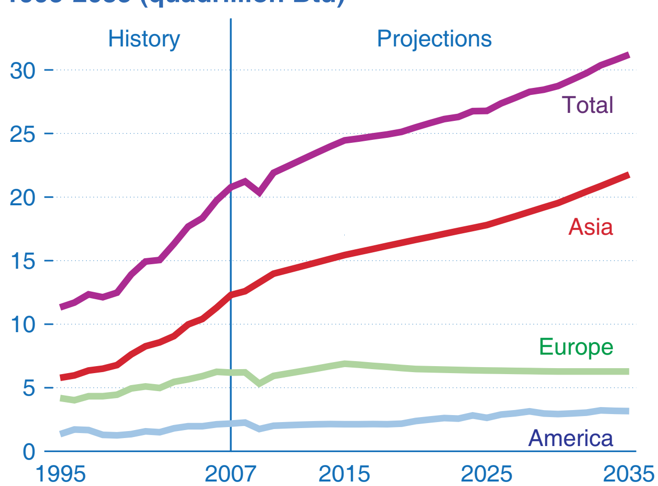
China began to increase its coal imports at the end of 2008, while accelerating the closure of the country's small, inefficient, and comparatively less safe mines in Shanxi Province. Shanxi has typically been China's top coal-producing region, and although it appears to have produced more coal in 2009 than in 2008, production was not sufficient to keep up with demand, creating coal shortages within the region that contributed to the need for imports. However, past consolidations in other Chinese provinces suggest that the country could quickly reopen small mines should international supplies tighten and international coal prices rise substantially.

The removal of coal import tariffs is a possible indication of China's intention to import large quantities of coal, at least in the short term, while Shanxi's coal industry is being restructured. An expected influx of dry bulk carriers beginning in 2010 may provide another short-term boost for Chinese coal imports by lowering the cost of bulk freight. The country may also manage any coal supply deficit in the future by importing more coal overland (trade that is not captured in Table 9) from new production sources in Mongolia and Russia. In addition, China plans to build strategic coal stocks in various provinces as a hedge against future volatility in coal import levels and prices.

China's steel production increased by an estimated 13 percent from 2008 to 2009. To feed the steelmaking process and compensate for production losses in Shanxi, China's coking coal imports rose from approximately 0.1 quadrillion Btu to 0.9 quadrillion Btu, and they are assumed to remain at roughly the same level through 2035. The Chinese government is planning to address issues of overcapacity in the steel industry in part through consolidation of various steel- and coke-making companies, which has potential to affect coking coal imports by moderating demand for coking coal. On the other hand, with new facilities strategically located in coastal areas (one possible outcome of consolidation), China's steel plants could have greater flexibility to use either domestic or foreign coal.

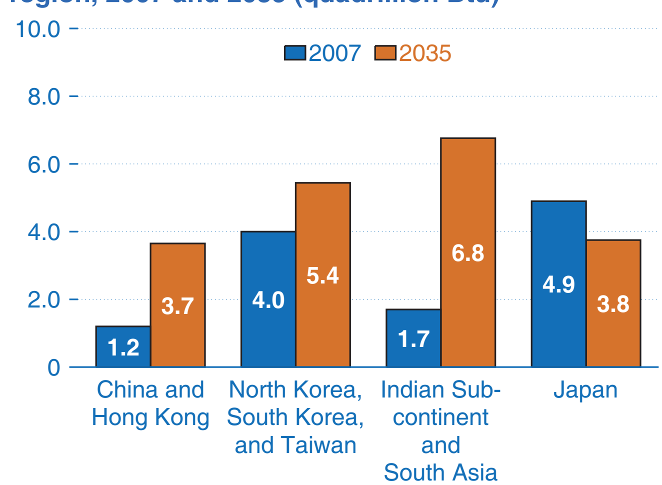
India also has been increasing its imports of coal while facing ongoing coal transportation challenges. Its improvements in infrastructure include the expanded use of smaller ports to satisfy increasing demand for coal imports. Like China, India increased its coal imports in both 2008 and 2009 (although preliminary data suggest that the growth in 2009 was much less than that in China). In 2035, India's coal imports in the Reference case are four times the 2008 level, spurred by rising imports of both coking and steam coal.

Figure 65. Coal imports by major importing region, 1995-2035 (quadrillion Btu)



Sources: SSY Consultancy and Reseach, Ltd., and EIA.

Figure 66. Coal imports to Asia by major importing region, 2007 and 2035 (quadrillion Btu)



Sources: SSY Consultancy and Reseach, Ltd., and EIA.

The large coal-fired electricity plants planned for India's coastal areas will be fueled by imported steam coal. The country is faced with domestic coal supply and quality issues and, while it is building new plants, its demand for coal imports continues to grow. Unfortunately, delays in meeting established construction schedules are commonplace in India, and transportation infrastructure issues abound. For instance, in 2009 India had difficulty handling coal imports at its river port of Haldia because of an unexpected loss of water depth. In order for tonnage to be handled at the port, larger ships have been diverted to deeper ports, where their coal cargos are transferred to smaller ships for delivery to Haldia [***19***].

India's planned infrastructure improvements include coastal port expansions at Goa and Paradip [***20***]. Freight capacity at Paradip is expected to increase from about 55 million tons in 2009 to 77 million tons in 2012, but recent bottlenecks at the port must be overcome in order for that goal to be achieved [***21***]. In addition, coal-handling capability at the port of Mormugao will be expanded from 6 million tons to 17 million tons by 2014 [***22***]. India completed the new port of Gangavaram in 2009, only one of two (the second being the Mundra port) capable of handling capesize vessels. Gangavaram already handled about 17 million tons of freight (not all of it coal) in 2009. In the long term, Gangavaram's owners would like to expand its freight handling capability to 221 million tons per year. The new port of Dharma, also capable of handling capesize ships, should begin operation by the end of 2010.

India has domestic resources of coking coal, but its quality is poor in comparison with foreign-sourced coking coal. India's long-term plans include expansion of its steel industry to between 165 and 198 million tons of raw steel output by 2020, up from about 62 million tons in 2008 [***23***], with increased imports of coking coal supporting the expansion. Some plans for new steelmaking capacity, such as ArcelorMittal's new coastal steel plant in Orissa, appear to have been delayed by land acquisition difficulties and environmental issues and thus are unlikely to add to India's demand for coking coal imports until after 2014. Largely because of its imports of coking coal, India surpass Japan as the world's largest importer of coal by 2025 in the *IEO2010* Reference case.

Europe, Middle East, and Africa

In the *IEO2010* Reference case, total coal imports to Europe (including the Middle East and Africa) in 2035 are about the same as in 2008 (Figure 66). With most European countries placing greater emphasis on natural gas in their power sectors, coal becomes a less significant component of the fuel mix for electricity generation. Europe's demand for lower sulfur coal (from South America and Eurasia, for example) will be tempered over time by the gradual addition of flue gas desulfurization equipment at existing coal-fired power plants.

Some European countries will import more coal to compensate for their own dwindling coal production, which will offset some of the decline expected for coal imports to other European nations. For example, Germany's planned closure of its remaining hard coal mines by 2018 results in increasing imports of coal for electricity generation [***24***]. In Turkey, electricity demand and steel industry growth also are projected to offset some of the decline in Europe's coal use. Over time, however, Turkey is expected to rely more heavily on electric arc furnace steelmaking technology, which does not require coking coal. Italy's conversion of power plants from oil to coal also offsets some of the decline in Europe's coal demand.

The Americas

In the mid- to long term, port expansions are expected to facilitate U.S. coal imports. In 2008, Kinder Morgan Energy Partners LP completed an expansion of annual capacity at its import terminal in Newport News, Virginia, by 6 million tons; and in late 2009, it received an air permit enabling it to expand its coal terminal in Jacksonville, Florida [***25***]. Keystone Coal Co. is planning a coal import terminal in Jacksonville, Florida, as well. With declining productivity and mining difficulties in Central Appalachia and rising domestic demand for coal, imports are expected to remain competitive for coastal States in the East and South. South America (Colombia, in particular) is expected to be an important source of U.S. coal imports.

Canada has been the largest importer of U.S. coal in recent years, but exports of U.S. steam coal to Canada in 2035 are projected to fall below their 2008 level. A portion of Ontario's coal-fired generating capacity is assumed to be shut down by 2035 for environmental reasons, as legislated by the Provincial government. (By 2014, if the plan proceeds, there could be a decline of 0.4 quadrillion Btu in U.S. exports of thermal coal to Canada.)

Brazil's steelmaking capacity increase in the Reference case, taking advantage of its domestic resources of iron ore but requiring increased use of coking-grade coal that the country does not produce domestically [***26***]. The United States, Canada, Australia, and southern Africa all provide a portion of the coal needed to meet Brazil's import requirements. Overall, South America's imports of coking coal—driven primarily by demand in Brazil—grow from about 0.4 quadrillion Btu in 2008 to 1.1 quadrillion Btu in 2035. Brazil and Chile account for most of the increase in thermal coal imports to South America through 2035.

Coal exports

Most of the world's coal trade is in the form of steam coal, at nearly 15 quadrillion Btu (about 70 percent of total coal exports) in 2008. The top five exporters of steam coal in 2008 were Indonesia, Australia, South America (primarily Colombia), Russia, and southern Africa (primarily South Africa). Although Indonesia currently is the world's largest exporter of steam coal, exports from Australia exceed those from Indonesia on a Btu basis in most years of the projection. In terms of coking coal, Australia, the United States, and Canada rank as the three top exporters and are expected to remain the top three through 2035. Poland, Vietnam, and China are expected to lower their coking coal exports in the long term—for Poland, largely because of geological difficulties, and for Vietnam and China, because increasing domestic demand for coal constrains exports.

Already the world's leading exporter of coal (steam and coking coal combined), Australia dominates future international coal trade in the Reference case as it continues to improve and expand its inland transportation and port infrastructure to expedite coal shipments to international markets. For instance, a new coal terminal at Kooragang Island in New South Wales will add about 66 million tons of capacity, about half of which is expected to be operational by 2011 [***27***]. Expansion of Queensland's Dalrymple Bay port in 2009 is expected to increase its annual export capacity from about 75 million tons to 94 million tons [***28***]. Australia remains the primary exporter of metallurgical coal to Asian markets, supplying about 77 percent of Asia's import demand for coking coal in 2035, compared with about 71 percent in 2008. Numerous mine expansions could add close to 100 million tons of coal capacity by 2015, equivalent to nearly one-quarter of Australia's coal production in 2008. As of 2009, Australia's primary supply choke point appears to be in rail movement from mine to port. Although some improvements in this area have already taken place, more needs to be done to accommodate the expected growth in coal exports.

Indonesia, with its relatively low-cost surface mines, has also demonstrated its potential for significant growth in coal exports. Despite this potential, Indonesia's government has been warning for years that it plans to restrict coal exports in favor of domestic coal use. The rate of export growth slowed in 2009, probably due to the slowdown in global economic activity rather than concerns about meeting domestic coal demand.

The Indonesian company Bumi Akit plans to add 37 million tons of export capacity over the next 5 to 6 years and is simultaneously involved in a rail project from its South Sumatran reserves to the port of Lampung. The rail link, with a planned capacity of 20 million tons, should begin operation by 2013. Another Indonesian company, PT Adaro Energy Tbk, also plans to expand coal production by about 44 million tons between 2009 and 2014 [***29***].

Over the long term, areas of uncertainty for Indonesian exports include the rate of growth in its domestic coal consumption; whether domestic coal demand is, in fact, given preference over coal exports; the adequacy of its internal transportation infrastructure; the continued development of new mines; and environmental concerns. In the Reference case Indonesia continues to be an important source of coal supply for other nations through 2035, but its exports increase only slightly, at an average annual rate of 0.4 percent.

South America remains the world's third-largest coal-exporting region in 2035, primarily as a result of continued increases in exports from Colombia. The government of Colombia expects the nation's coal production to reach 160 million tons by 2019, up from about 87 million tons in 2008 [***30***]. The expansion will require sizable investments in mine capacity, rail infrastructure, and port capacity. Drummond Coal is now producing from its El Descanso mine, and it expects ultimately to attain export production of 40 million tons per year through 2032 [***31***]. The El Hatillo mine is planning to increase production from 1.8 million tons to 4.5 million tons by 2011 [***32***].

Increasing coal transportation infrastructure is also a concern for Colombia. There is a proposal to build a tunnel that would expedite coal transportation via truck to Colombia's Pacific Ocean port of Buenaventura when it is completed in 2013. Another planned infrastructure project, the Carare railway, now appears to be at risk because the government has decided not to provide financial support for the project [***33***], which was intended to facilitate coal transport from central Colombia to the Caribbean coast. Other expansion projects on Colombia's Caribbean coast appear to be on track, including a coal terminal at the port of Cienaga, Puerto Nuevo, ultimately handling 66 million tons per year, roughly one-half of which would be available by 2013 [***34***]. Brazil's MPX is planning a coal export terminal along the Colombia's Atlantic seaboard with a capacity of 20 million tons per year [***35***]. An expanded river-to-port terminal at Barranquilla, Colombia, with an annual capacity of about 39 million tons, is also planned [***36***].

Many of Colombia's port expansions lie on the Caribbean near the eastward opening of the Panama Canal. Begun in 2008 and slated for completion by 2015, the Panama Canal expansion should enhance opportunities for coal exports from both the United States and South America traveling westward to Asian markets. The so-called "post-panamax" vessels, which are capable of holding about 20 percent more than current panamax vessels, will be able to transit the Canal. Because many ports may not be able to accommodate the larger vessels without dredging, however, some opportunities could be limited.

South Africa's coal exports have remained flat over the past few years, primarily as a result of domestic infrastructure constraints; however, coal mining is expected to continue playing an important role in South Africa's economy. Delays in the scheduled expansion of the Richards Bay Coal Terminal to an annual productive capacity of 100 million tons have kept South Africa from increasing coal exports in recent years, but the project is scheduled for completion by the end of 2010[*37*]. Even with completion of the expansion, export levels still may fall short of expectations because rail capacity into the port is limited. An additional Richards Bay terminal with a capacity of 10 million tons has also been proposed [*38*].

Rail bottlenecks from coal basins to port facilities also appear to be Russia's primary limitation in its efforts to expand exports. Nevertheless, Russia has managed to triple its seaborne coal exports from 2000 levels to a total of 76 million tons in 2008. The Russian mining and steel production company, Mechel, is on track to begin operations at Russia's Elga coking coal deposit in 2010 and ultimately plans to produce 27 to 30 million tons per year [*39*]. Russia's coal exports to Asia will be facilitated by capacity expansion at the new Pacific port of Muchka, where SUEK (Siberia's coal energy company) has built about 13 million tons of an annual export capacity, and Mechel has plans for about 28 million tons of export capacity at the new Muchka Bay Terminal 2 [*40*]. As in 2008, Eurasia (primarily Russia) supplies 8 percent of the coal traded internationally in 2035.

The African countries of Mozambique and Botswana are expected to play an emerging role in world coal trade, as importing countries seek to secure additional and diversified sources of supply. For example, India's Tata Steel, Brazil's Companhia Vale do Rio Doce (CVRD), and Australia's Riversdale Mining all have financial stakes in mine operations in the Moatize basin of Mozambique [*41*]. The Moatize project, expected to be completed by 2011, will produce between 9 to 14 million tons of marketable coking coal and 3 to 5 million tons of thermal coal [*42*]. An expansion of the port of Beira in Mozambique to handle an annual capacity of about 20 million tons is also planned, and the rail link between Moatize coal basin and Beira (Sena Railway) is being updated [*43*]. Landlocked Botswana is also interested in expanding coal mining and in constructing a railroad to connect inland coal mines to an Atlantic port on the Namibian coast.

U.S. coal exports decline in the *IEO2010* Reference case from their high 2008 levels but remain steady, contributing an average of about 1.6 quadrillion Btu per year to international coal supply through 2035. The geographic distance of the United States from Asian markets—where much of the growth in coal demand is centered—places it at a distinct disadvantage relative to other countries with large coal reserves (see box on page 72). The comparatively high transportation costs associated with shipping coal from the United States to Asian markets mean that U.S. coal exports cannot typically compete economically in that region. Thus, the United States remains a marginal supplier of world coal trade throughout the projection period.

There have been recent shipments of coal to Japan from Alaska, but the volumes have been small; likewise, eastern U.S. miners have shipped small volumes to Asian markets. There is also some possibility that smaller coal shipments to Asia might be accommodated at other bulk terminals in Washington State in lieu of a dedicated western coal terminal. Some coal has also shipped to Asian markets through Canada's Westshore Terminal.

World coal reserves

Total recoverable reserves of coal around the world are estimated at 909 billion tons—reflecting a current reserves-to-production ratio of 129 years (Table 10).[20] Historically, estimates of world recoverable coal reserves, although relatively stable, have declined gradually from 1,145 billion tons in 1991 to 1,083 billion tons in 2000 and 909 billion tons in 2008 [*44*]. Although the decline in estimated reserves is sizable, the large reserves-to-production ratio for world coal indicates that sufficient coal will be available to meet demand well into the future. Further, because recoverable reserves are a subset of total coal resources, recoverable reserve estimates for a number of regions with large coal resource bases—notably, China and the United States—could increase substantially as coal mining technology improves and as additional geological assessments of the coal resource base are completed.

The most recent assessment of world coal reserves includes a substantial downward adjustment for Africa, from 55 billion tons reported in the 2007 edition of the World Energy Council's *Survey of Energy Resources* to 35 billion tons in the 2009 interim update [*45*]. The update is based on a new estimate for recoverable reserves in South Africa, which was derived on the basis of factors that include: a reduction in estimated reserves resulting from the subtraction of cumulative production by coalfield for the years 1982 through 2007 from previously completed estimates of reserves; and some additions to the reserve base resulting from several new assessments of coal resources in the Waterberg, Springbok Flats, Limpopo, and Free State coalfields.

[20] Recoverable reserves are those quantities of coal which geological and engineering information indicates with reasonable certainty can be extracted in the future under existing economic and operating conditions. The reserves-to-production ratio is based on the reserves estimates and data on world coal production for 2007 shown in Table 9.

Future role of the United States in world coal trade

U.S. coal exports increased each year from 2002 to 2008 at an average annual rate of 12.8 percent, to 82 million tons in 2008. Some analysts have viewed the sharp increase in U.S. exports as an indication of the growing importance of the United States as a world coal supplier. There has also been speculation that China's growing demand for coal will support this trend in the future. However, U.S. coal is a relatively high-cost supply source when shipped to Asian markets, and in the long term U.S. coal will be competing in the Chinese market with lower cost suppliers, notably Australia and Indonesia among others. U.S. exports compete most strongly in European markets and then only when less expensive options are unavailable. In *IEO-2010*, the United States remains a marginal coal supplier over the long term, responding to short-term disruptions or spikes in demand rather than significantly expanding its market share of world coal trade.

International coal trade patterns can be parsed into two distinct regions, the Atlantic region and the Pacific region. The Americas and Europe are the primary demand centers for international coal trade in the Atlantic region. Asia, dominated by Japan, South Korea, India, and China, is the demand stakeholder in the Pacific region. Historically, geography has been a critical component in determining which suppliers serve which markets, with most suppliers primarily serving only one region. The United States is considered a marginal or "swing" supplier to both markets but rarely participates in the Pacific market, meaning that the United States produces coal at a higher delivered cost than other international suppliers and "swings in" to satisfy demand only when a supply shortage occurs.

Competition is an important factor in assessing the ability of the United States to take a larger share of world coal trade in the future. The cost of production, primarily the expense of mining, is just one of the costs involved in international trade. In terms of the cost of production, the United States tends to be among the more expensive worldwide, primarily because most coal exports come from the Appalachian region, which has been mined more extensively than other U.S. coal basins and generally has higher production costs. Beyond the costs of production, transportation costs associated with moving export coal to port can also be substantial, adding as much as an additional 30 to 50 percent to the total cost for Appalachian coal. Ocean freight rates to transport coal from the United States to Asian markets tend to be volatile and are as much as 40 percent higher than the freight costs for transporting coal from Australia to Asia. As a result, the United States represents a less attractive option for satisfying Asian coal demand in the long run.

U.S. coal exports to Asian markets might be more competitive if large volumes of western coal could be exported from the U.S. West Coast. However, the lack of a dedicated large coal terminal on the West Coast makes it less likely that such an expansion will occur. Previous unsuccessful efforts to operate a western coal terminal also make new western coal ports less likely. In the late 1990s, substantial investments were made at the Los Angeles Export Terminal to support coal exports, but the terminal closed in 2003 when the anticipated surge in U.S. coal exports to Asian markets did not materialize. While Asia's coal import demand grew during that period, its demand for U.S. coal did not.

The Atlantic markets of Europe and Canada currently account for the largest portion of U.S. coal exports (approximately three-fourths of total exports in recent years). In 2008, the largest increases in U.S. coal exports were destined for Europe rather than China. On a worldwide basis, international coal trade in 2008 was affected by significant supply disruptions in several key coal-exporting countries. Floods in Indonesia and Australia affected mine operations, electricity shortages closed mines in South Africa, and there were shortages of rail cars in Russia and long queues at Australian ports. Some of the problems were unexpected, one-time events. For supply bottlenecks that are ongoing, infrastructure improvements are already being undertaken.

In any case, temporary supply problems did raise the perception of ongoing limited global supplies, and as a result the price of coal rose steeply. In 2008, the limited amount of coal that typically flowed from suppliers in the Pacific region to Europe was redirected to importers in the Pacific region, causing a ripple effect into the Atlantic region, where the United States was able to help fill the void by increasing its exports to consumers in the Atlantic region. The circumstances contributing to increased U.S. exports in 2008 are anomalies, however, and not expected to be sustained in the long term. In fact, recently published data indicate that U.S. coal exports contracted by 27 percent in 2009—with European imports from the United States declining by approximately 25 percent.[a]

(continued on page 73)

[a]U.S. Energy Information Administration, *Quarterly Coal Report*, DOE/EIA-0121(2009/4Q), Table 7. U.S. Coal Exports, web site www.eia.gov/cneaf/coal/quarterly/html/t7p01p1.html.

Future role of the United States in world coal trade (continued)

In the past decade, several new coal suppliers have emerged to compete with the United States in supplying coal to the global marketplace. Colombia is the key U.S. rival in the Atlantic market and is typically a lower cost producer than the United States. Colombia's domestic coal consumption is low, and so its investments in the coal industry are dedicated to increasing coal exports. Russia also has increased its market share of coal supplied to European countries, the primary market for U.S. coal exports. Russia has substantial reserves of metallurgical coal, used in the steelmaking process, which is a market where the United States has been more competitive internationally. Moreover, in the long term Europe as a region is expected to rely less on coal to meet its energy needs, so that the United States will face increasing competition from lower cost Colombian and Russian supplies to satisfy a declining European market for coal.

In the Asian markets, Australia has been systematically expanding its export capability. In the next few years alone, Australian mining companies are planning to expand their mining capacity by approximately 100 million tons. Even in 2008, a year of high U.S. coal exports, Australia's coal export volume was more than 2.5 times the U.S. volume. Russia is also investing in infrastructure, including ports to serve the Asian market. Its proximity to Asian importers could allow Russia to become a key Asian supplier. Mongolia may also be an important overland source of coal imports for China, and Mozambique will soon be entering the coal trade arena with its planned exports of both metallurgical and thermal coal.

The United States is not a major supplier of coal to China, but China has an indirect impact on the Atlantic market, and there could be years through 2035 in which events trigger temporary increases in U.S. coal exports to China. China's demand for foreign coal is driven by its growing coal consumption and how its domestic coal production costs compare with international coal prices. Given the limits on its own domestic coal production, any unexpected capacity problem could induce short-run bursts in China's import demand and, less directly, increases in global coal prices.

The higher the global prices, the more likely it is that the United States, as a high-cost supplier, will increase its coal exports. China also has the option, if it decides that international coal prices are too high, of allowing its less efficient domestic coal mines to operate. Because the United States is a relatively high-cost supply source when its coal is shipped to Asian markets, other suppliers—and not the United States—are expected to meet most of China's demand for coal imports from 2007 to 2035.

Table 10. World recoverable coal reserves as of January 1, 2008 (billion short tons)

Region/Country	Recoverable reserves by coal rank				2007 production	Reserves-to-production ratio (years)
	Bituminous and anthracite	Subbituminous	Lignite	Total		
World Total	**452.9**	**291.4**	**165.1**	**909.4**	**7.0**	**129**
United States[a]	119.6	108.7	33.3	261.6	1.1	228
Russia	54.1	107.4	11.5	173.1	0.3	543
China	68.6	37.1	20.5	126.2	2.7	46
Other Non-OECD Europe and Eurasia	49.1	19.0	27.3	95.3	0.3	290
Australia and New Zealand	40.6	2.5	41.5	84.6	0.4	195
India	59.5	0.0	5.1	64.6	0.5	122
Africa	35.1	0.2	0.0	35.3	0.3	127
OECD Europe	9.3	3.4	19.0	31.7	0.7	48
Other Central and South America	7.7	1.1	0.0	8.8	0.1	102
Other Non-OECD Asia	2.5	2.8	4.5	9.8	0.4	24
Brazil	0.0	7.8	0.0	7.8	0.0	1,182
Canada	3.8	1.0	2.5	7.3	0.1	96
Other[b]	3.0	0.3	0.1	3.4	0.0	181

[a]Data for the United States represent recoverable coal estimates as of January 1, 2009.
[b]Includes Mexico, Middle East, Japan, and South Korea.
Sources: World Energy Council and EIA.

Although coal deposits are widely distributed, 82 percent of the world's recoverable reserves are located in five regions: the United States (29 percent), Russia (19 percent), China (14 percent), other non-OECD Europe and Eurasia (10 percent), and Australia/New Zealand (9 percent). In 2007 those five regions, taken together, produced 4.9 billion tons (95.8 quadrillion Btu) of coal, representing 71 percent (74 percent on a Btu basis) of total world coal production [*46*]. By rank, anthracite and bituminous coal account for 50 percent of the world's estimated recoverable coal reserves on a tonnage basis, subbituminous coal accounts for 32 percent, and lignite accounts for 18 percent.

Quality and geological characteristics of coal deposits are important parameters for coal reserves. Coal is a heterogeneous source of energy, with quality (for example, characteristics such as heat, sulfur, and ash content) varying significantly by region and even within individual coal seams. At the top end of the quality spectrum are premium-grade bituminous coals, or coking coals, used to manufacture coke for the steelmaking process. Coking coals produced in the United States have an estimated heat content of 26.3 million Btu per ton and relatively low sulfur content of approximately 0.8 percent by weight [*47*]. At the other end of the spectrum are reserves of low-Btu lignite. On a Btu basis, lignite reserves show considerable variation. Estimates published by the International Energy Agency for 2007 indicate that the average heat content of lignite in major producing countries varies from a low of 5.9 million Btu per ton in Greece to a high of 13.1 million Btu per ton in Canada [*48*].

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